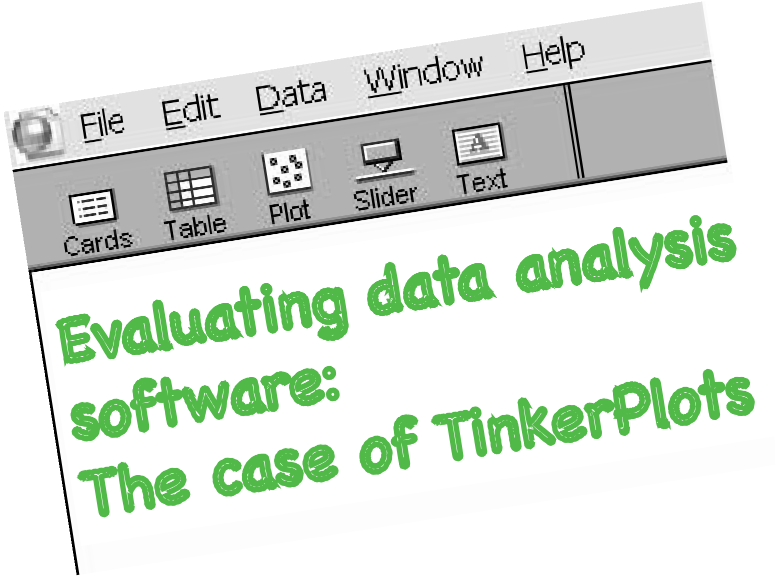


# Evaluating data analysis software: The case of TinkerPlots

Noleine Fitzallen applies a framework for evaluating software to a well-known data exploration computer program.

The ever increasing availability of mathematics education software and internet-based multimedia learning activities presents teachers with the difficult task of deciding which programs are best suited for their students' learning needs. The challenge is for teachers to select pedagogical products that not only promote significant mathematical learning but also offer user-friendly functions, and are useful in the classroom. With the aim of assisting teachers in the selection process, this article reports on a framework that may be useful for evaluating software and multimedia products. As an example, an evaluation of data-analysis software, *TinkerPlots Dynamic Data Exploration* (Konold & Miller, 2005), is presented.

In the early stages of implementing computers and software into education, criteria for evaluating software focused on management issues such as compatibility and operating system requirements. These were important features of software that need to be considered but from a teacher's perspective provided little or no guidance as to the educational benefits. Often decisions to use particular software were based on anecdotal evidence and the hard sell rhetoric of publishers.

More recently, efforts to provide teachers with the tools to determine which products may be useful have focused on evaluating internet-based multimedia learning activities. *The APMC, Technology Focus Issue, June 2006,11*(2) provided a good example of one such evaluation. Handal, Handal and Herrington demonstrated how the evaluation of online resources, which focused on pedagogical features, interface design, navigation, and user's control provided information that could be used to inform teachers' choices. Their checklist may be transferable to software programs but is limited in that it only considers generic aspects of software. Although applied to mathematical learning activities, it is not specific to the learning of mathematics concepts.

With the notion that visual representations facilitate the development of mathematical thinking, Kidman and Nason (2000) developed a set of seven principles, *Principles for Analysing Visual Representations*, to

guide the evaluation of internet-based multimedia mathematics activities. The principles were applied to 550 mathematics activities and proved to be very useful in describing the learning potential of the activities. Although the principles were developed with mathematics content in mind, they did not focus on any particular strand of mathematics.

With the mathematical content area of Chance and Data and the application of graphing software in the mathematics classroom being of interest, Fitzallen and Brown (2006) developed a framework for evaluating software. The framework, *Enabling Aspects of Statistical Software*, was developed from two perspectives. First, the *Principles for Analysing Visual Representations* (Kidman & Nason, 2000), which focused on visual representations and second, the *Model of Graphing in an ICT Environment* (Fitzallen, 2006), a model of statistical thinking and reasoning, were utilised. The resulting framework, *Enabling Aspects of Statistical Software*, is presented in Table 1.

The framework (Table 1) recognises the notion that data-analysis software should allow students to construct and deconstruct visual representations that assist in the exploration of statistical concepts. In doing so, the learning environment should not only support students' thinking but also assist in the reorganisation of their thinking as they develop an understanding of statistical concepts. In the following section, *TinkerPlots Dynamic Data Exploration* (Konold & Miller, 2005) is presented. The evaluation illustrates how the framework can be used to inform teachers about the ways in which software supports student learning.

## Evaluating software against the framework

*TinkerPlots Dynamic Data Exploration* (Konold & Miller, 2005) is recently released data-analysis software designed specifically for students in upper primary and middle years of schooling. It gives students a dynamic and interactive learning environment in which they can construct and interpret graphs. The purpose of *TinkerPlots* is to provide a learning environment in which students have the opportunity to develop an understanding of statistical concepts. It is, however, important to evaluate critically the visual representations afforded by *TinkerPlots*. This may be of assistance when determining in what ways *TinkerPlots* may assist students to construct mathematical knowledge.

The following evaluation uses specific examples to demonstrate how *TinkerPlots* complies with each of the sections of the *Enabling Aspects of Statistical Software* framework. Although not explicitly stated in the evaluation, some of the functions of *TinkerPlots* comply with multiple *Enabling Aspects*. It should be noted that the examples given are not the only ways in which *TinkerPlots* exemplifies each of the *Enabling Aspects.*

### Enabling Aspect 1.

When initialised, *TinkerPlots* presents a clean and uncluttered interface. The screen consists of a blank white page with a menu bar at the top of the screen (Figure 1). To import or enter data into *TinkerPlots*, it is necessary to place the cursor over the "Cards" icon, click the mouse, and drag the

Table 1. Enabling Aspects of Statistical Software (Fitzallen & Brown, 2006)

| No. | Enabling Aspects |
|---|---|
| 1 | Software interface is accessible and features of the software are easy to use. |
| 2 | Software assists recall knowledge and data can be represented in different and multiple forms. |
| 3 | Software facilitates the process of translating between mathematical expression and natural language. |
| 4 | Software provides extended memory when organising and reorganising data. |
| 5 | Software provides physical/iconic environment that provides multiple entry points for abstraction of concepts. |
| 6 | Software provides visual representations that can be used for both interpretative and expressive learning activities. |

"Cards" icon into the blank space. Releasing the mouse places a stack of data cards onto the screen (Figure 2). The drag-and-drop function is also used to place the other items in the menu onto the screen, as required. This enables students to introduce the different visual representations onto the screen in stages; therefore, building an interface that is meaningful to them. When encountering *TinkerPlots* for the first time, there is the potential for the blank screen to be confronting as there are no visual clues as to where to start. Additionally, as there is a propensity for commercial software packages to utilise drop-down menus and double-click mouse functions to open objects, the drag-and-drop function to access the features of the software would be unexpected. It is, however, easy to learn how to control the drag-and-drop function.

*TinkerPlots* has an extensive 'Help' section that incorporates a search function, which is easy to use. Additionally, the software has five tutorials that demonstrate how to use the basic features. These are in the form of movies, which only take a few minutes each to view. The tutorials can be accessed within the program or can be viewed-from the *TinkerPlots* website (www.keypress.com). *TinkerPlots* also has a number of data sets saved within the program. Some of these are already set up to be used as teaching and learning activities whereas others are practical demonstrations of some of the capabilities of *TinkerPlots*.

In summary, *TinkerPlots* complies with the need for software to have an interface that is accessed easily. It has a clean, uncluttered interface and provides easy access to a number of different data representations. Although there may be a momentary hesitation when using *TinkerPlots* for the first time, familiarity with the drag-and-drop function is quickly acquired. Viewing the tutorials before starting TinkerPlots may alleviate problems associated with the use of the drag-and-drop function.

## Enabling Aspect 2.

*TinkerPlots* includes a stacked data card system for the organisation of case-based data. Information about the attributes of an individual case is presented on a single card and there is one card for each case in a data set (Figure 3). Once the first card in the data set is organised with the nominated attributes and the units of measure, the following cards will display the same information. For subsequent cases it is necessary only to enter the actual values of the attributes into the cards (Figure 4). Clicking the cursor on the direction arrows at the top of the data cards provides access to other cases in the data set.

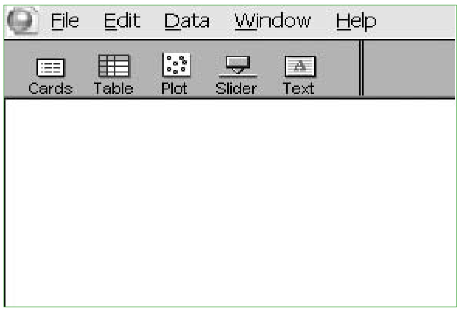


Figure 1

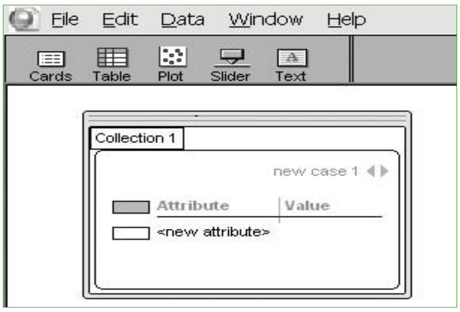


Figure 2


Figure 3


Figure 4

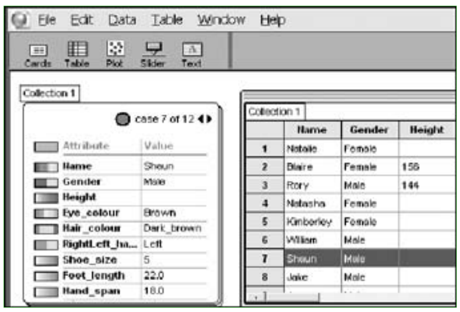


Figure 5

Data entered into the data cards are entered automatically into a spreadsheet (Figure 5). There is, however, the option of entering the data directly into a spreadsheet. This facility reverses the process and displays the data in the stacked data cards automatically. Additionally, data can be imported directly into *TinkerPlots* from MSExcel spreadsheets, provided the data are organised with the variables horizontally and the cases vertically. Again, as the data are imported they are organised automatically into both the data cards and the spreadsheet format. Additional to the data cards and the spreadsheet, graphical representations can be constructed from the data (see also Enabling Aspects 4 and 6).

Clearly, *TinkerPlots* provides a learning environment that facilitates the display of multiple representations of data. The ease at which students can enter data into the data cards and the spreadsheet simultaneously provides multiple representations from which to recall facts and information. Importantly, students have the opportunity to choose which representation is most meaningful to them.

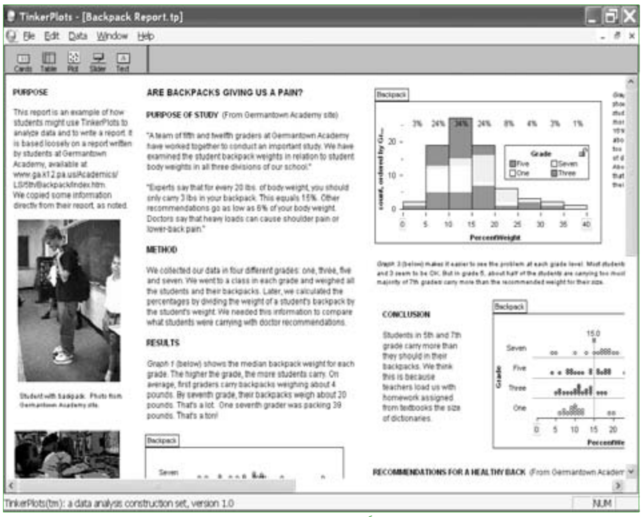


Figure 6

## Enabling Aspect 3.

*TinkerPlots* has an interface in which it is possible to create multiple graphical presentations, import digital images, display tables of results, and add written commentaries within the one screen, as a statistical investigation is conducted (Figure 6). The capacity to display various forms of information in the screen allows for the context of an investigation to be transferred easily to the software interface.

Maintaining the connections between the context of the data and the graphical representations may assist in developing an understanding of the statistical concepts conveyed in the data. Hence, TinkerPlots promotes the use of natural language to describe the context of an investigation. Additionally, direct and simultaneous access to the graphical representations and the ability to contribute written responses to the interface of *TinkerPlots* facilitates the use of statistical language.

## Enabling Aspect 4.

Graphical representations are constructed in *TinkerPlots* from either the data cards or the spreadsheet. Data icons first appear in a haphazard arrangement in the plot window. The icons are coloured along a gradient for the attribute selected on the data card, for example the number of days it takes for seeds to germinate. Dragging-and-dropping an attribute into the horizontal axis of a “Plot” window sorts the data into two bins (Figure 7). Once this is established it is necessary to drag-and-drop one of the data points to the right to sort the data into more bins, each with a smaller range than when there are fewer bins (Figure 8). Dragging the data point even further to the right produces a graph with a continuous scale and the data are no longer sorted within particular ranges. Stacking the data vertically produces a stacked dot plot (Figure 9). Covariation graphs are created in the same way by dragging an attribute into both the horizontal and vertical axes of a “Plot” window.

The data points in a graphical representation in TinkerPlots are manipulated by the drag-and-drop function in order to change the scale of the graph. Changes are quick and fluid, and are viewed as animations. Additionally, the transformation of a dot plot to a histogram is made easily by changing the shape of the icons representing the data from a dot to a fused bar. Actions such as these change the scale and the form of the graph quickly. Although the scale is determined initially by the software it can be changed to represent a different range of values. The ease with which graphical representations are created, manipulated, and altered in *TinkerPlots* is extraordinary. This creates

an environment where multiple graphs can be constructed and compared easily.

Once a graph is constructed, functions such as mean, mode, and median can be applied to the data. The numerical calculations for these concepts of centrality are performed automatically by the software and are represented on graphs by an icon and/or numerical value. This allows students to explore what these concepts mean in terms of the data without having to focus on the rules for determining the numerical value.

Many features of *TinkerPlots* assist in distributing the cognitive load of processing data between the student and the software, allowing the student to focus on the interpretation of the data rather than the creation of the graphs. Therefore, *TinkerPlots* provides extended memory when organising and reorganising data. This has the potential to support students' thinking as they work through the data-analysis process.

## Enabling Aspect 5.

*TinkerPlots* displays data in three main forms; that is, case-based data cards, spreadsheets, and graphs. It is possible to display all three visual representations within *TinkerPlots* at the same time and the data can be accessed from each of the representations as required when exploring the statistical concepts associated with the data. Highlighting an individual data point on a graph will display automatically the case data card associated with that particular data point. It also highlights all the data for that particular case in the spreadsheet (Figure 10). Conversely, selecting a case in the data cards will highlight the associated data for that case in the graph and in the spreadsheet. This provides an explicit connection between the data and the graphical representations. As a result, *TinkerPlots* has the potential to help students develop an understanding of the relationship between the data and the visual representations. This is facilitated by being able to access the data from multiple entry points.

## Enabling Aspect 6.

Expression is the process of crafting visual representations to convey meaning (Kidman & Nason, 2000). *TinkerPlots* allows students to construct visual representations that are meaningful for them by enabling them to maintain control of the construction and manipulation of graphs. The construction of both simple and complex graphs by performing actions such as sorting data into categories, or ordering the information according to an attribute assists in the mean-making process.

In relation to interpretative activities, the box plot, mean, median, sorting, and filtering of data functions all contribute to the way the user can interpret data. An additional feature that facilitates the interpretation of data is the way in which the software displays the data in multiple categories within the same graph. An example is provided in Figure 11. In this example the association between gender and height is displayed in a stacked dot plot. The data are sorted according to gender and a hat plot is used to compare the association between the males and females in the group. The hat plot representation in *TinkerPlots* is a precursor to the introduction of box plots and can be used to describe general differences in the shapes of distributions.

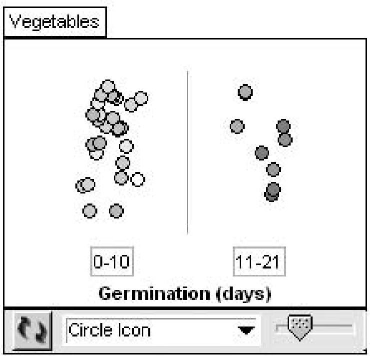


Figure 7

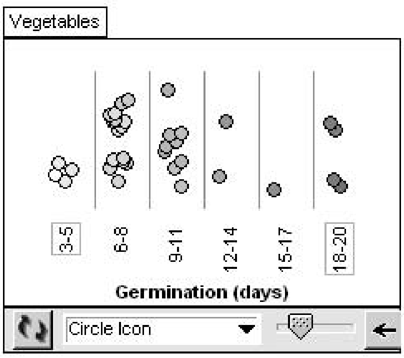


Figure 8

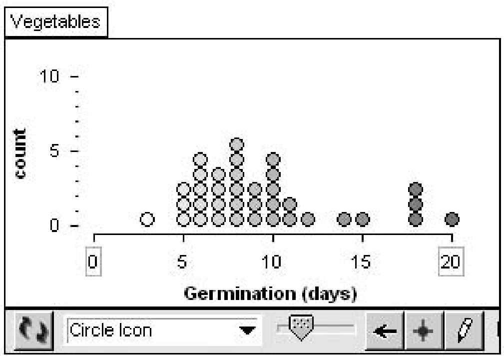


Figure 9

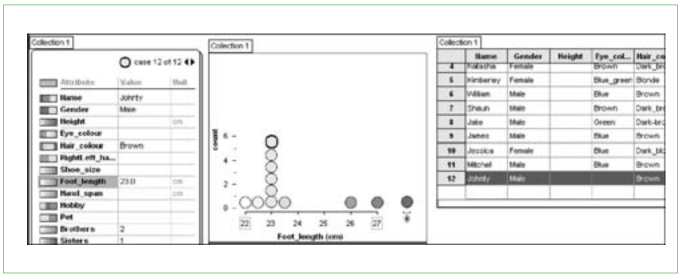

Figure 10

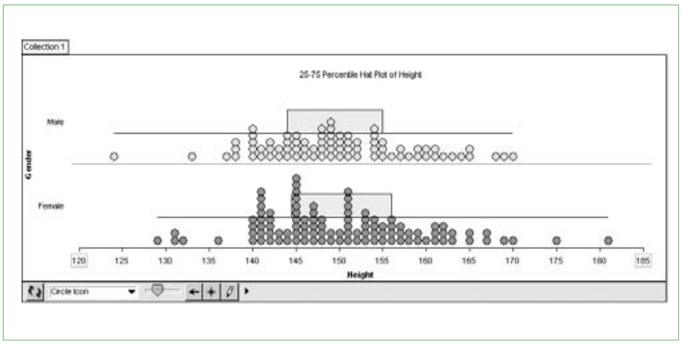

Figure 11

## Conclusion

The evaluation of the main features of *TinkerPlots* presented in this article has identified how some of the features of the software may assist students in the development of statistical thinking and reasoning. From the evaluation it appears that *TinkerPlots* provides an interactive learning environment in which students can easily engage with. It places the control of the creation of graphs in the hands of students, allowing them to create meaningful graphical representations. The interpretation of those graphs is supported by easy access to statistical functions such as, mean, median, and mode. Clearly, *TinkerPlots* provides a cohesive learning environment, which is appropriate for students in upper primary and middle years of schooling. Notably, it promotes and maintains the connections between the data, the context, and the analysis of a statistical investigation.

It is not possible to convey the dynamic nature of *TinkerPlots* in a written article but should this article spark interest in using *TinkerPlots* with students, an Instructor's Evaluation Edition is available on the *TinkerPlots* website (www.keypress.com).


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